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Concurrent Delays and Apportionment of Damages

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Abstract: This paper focuses on the subject of concurrent delay from a general contractor-subcontractor perspective. When there is a concurrent delay by multiple subcontractors, or between the general contractor (GC) and other subcontractor(s) (subs), there has not been a uniform approach as to how the liquidated damages (LDs) are apportioned. Previous research seems to ignore this issue. This paper first reviews some relevant court cases. Using a warehouse project as a case study, it then examines different practices that the GC could take in apportioning damages of concurrent delays to both him/herself as well as to the responsible subcontractors. Results are very inconsistent between and within the apportionment practices. This supports an alternative hypothesis that apportionment is an important issue. Practitioners should specify which apportionment practice will be used and under what circumstances it will be applied in their subcontracts. Researchers may develop a more consistent and reliable approach for this type of apportionment.

CE Database Subject Headings: Claims; Contracts; Delay time; Contractors; Court decisions; Damage assessment; Litigation; Subcontractors

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Introduction

Concurrent delay is an interesting but challenging issue in construction claims. When discussing concurrent delays, one usually relates them to overlapping delays attributable to both the owner and general contractor (GC). In these circumstances, the owner typically extends the completion date but no compensation is awarded to the GC. Owners, therefore, often try to demonstrate that a delay is either third party-caused or a concurrent delay, and thus excusable but noncompensable (Zack, 2001). For that reason, calls for apportionment of concurrent delays and their damages are increasingly heard in the construction industry (i.e. Kraiem and Diekmann 1987; Kelleher 2005).

Nonetheless, the subject of concurrent delay at the subcontract level is equally important though it has been rarely discussed in literature. When a delay is deemed to be caused by the GC the owner will assess LDs per the terms of the contract. If the delay is caused by a single subcontractor (sub) or supplier (hereafter subcontractor also including supplier), the GC will pass those LDs to the responsible subcontractor, assuming that there are flow-through provisions in the GC-subcontractor contract. However, when there is a concurrent delay by multiple subcontractors, or between the general contractor and other subcontractor(s), there has not been a uniform approach as to how the LDs are apportioned. Because previous writers have glossed over concurrent delays at the subcontract level, a null hypothesis is that apportionment is not an important issue because attention has not been devoted to the subject by previous writers

Apportionment of concurrent, inexcusable delays is essential to general contractors who have to distribute delay responsibility among their subcontractors and suppliers (Bramble and Callahan

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2000). This paper first reviews the literature of concurrent delays and some relevant legal cases. It then proposes and examines the different approaches that the GC could take in apportioning damages of concurrent delays to both him/herself as well as to the responsible subcontractors. A hypothetical warehouse construction project where the GC would be accessed LDs is used to demonstrate the proposed apportionment approaches. That is, the objective of this paper is to show that different approaches yield different results and that apportionment is a complicated and judgmental issue. The industry practitioners would benefit from understanding different approaches presented in this paper and choosing an appropriate one for their subcontracts.

Concurrent Delays

Concurrent delays occur frequently, particularly at the peak of a project when multiple-responsibility activities are being performed simultaneously (Baram 2000). Analysis of schedule delays takes a major leap in complexity when there are multiple sources of delay with interrelated impacts (Galloway and Nielsen 1990; Kutil and Ness 1997). This section reviews the concept of concurrent delays, conditions of its occurrence, and apportionment of concurrent delays.

The Concept of Concurrent Delays

Schedule delay analysis is among the most challenging tasks in claims-related issues. This analysis becomes more complicated when concurrent delays have occurred in the project. Navigating the seas of concurrent delays is possibly the most challenging task faced by a construction lawyer (Hughes and Ulwelling 1992).

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Concurrent delay is customarily described as two or more delays that occur at the same time, either of which would cause a project delay. If either of them had not occurred, the project schedule would have been delayed by the other (Stumpf 2000). However, there is no consistent agreement on what concurrent delay actually means (Peters 2003). Another definition is that delay concurrency occurs when two or more separate causes of events delay the project within a specific time period (Baram 2000). Simultaneous delays, commingled delays, and intertwined delays are other terms used to interchange for concurrent delays.

Conditions for Occurrence of Concurrency

Hughes and Ulwelling (1992) reveal that the word "concurrent" describes either temporal concurrence or causal concurrence. They also claim that: (i) while the word "concurrent" may appropriately apply to temporally concurrent events, temporal concurrence is irrelevant for the purpose of attempting to assess liability for project delay; and (ii) the actual issue in construction is whether two events are concurrent in their causation of the project delay.

Differentiation between concurrent delays and those which simply absorb float requires a thorough knowledge of the facts, an understanding of the basis of CPM analysis, and a determination of whether three key factors exist: (i) the delays are critical; (ii) the delays are independent; and (3) the delays occur during the same time period (Boe 2004). More broadly, Ponce de Leon (1987) points out the occurrence of concurrency in construction as follows:

- Two unrelated delays taking place in an overlapping timeframe are truly concurrent only if both delays fall on parallel critical paths.
- Two unrelated delays arising at quite different timeframes are ultimately concurrent if they fall on two as-built critical paths.

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Apportionment of Concurrent Delays

Analysis of concurrent delays raises various issues. This is because both owners and contractors employ concurrent delays as a strong defense tool against each other (Baram 2000). For instance, owners use them to protect their interest in obtaining liquidated damages, while contractors use them to neutralize or waive their inexcusable delays and hence avoid damage entitlement (Baram 2000).

Courts, boards, practitioners, researchers are generally inconsistent in terms of both definition, as mentioned earlier, and apportionment of concurrent delays. A recent empirical study (Scott and Harris 2004) shows that there is wide divergence among contractors, contract administrators, and claims consultants about issues related to concurrent delays. A summary of law cases that treated concurrent delays differently can be found in James (1991).

General views consider concurrent delays as being similar to excusable delays. That is, contractors are entitled time extension only. When a compensable delay is concurrent with an inexcusable delay, this scenario follows an "easy rule" or "contributory negligence". However, a recent trend advocates an equitable apportionment when compensable and inexcusable concurrent delays occur. This trend is described as "fair rule" (Kraiem and Diekmann 1987) or "comparative negligence" (Hughes and Ulwelling 1992). Fair apportionment means apportionment of days and/or dollars. These different rules can be derived from two different doctrines: the doctrine of contributory negligence and the doctrine of comparative negligence (Hughes and Ulwelling 1992). Ibbs and Nguyen (2007) propose an approach for quantifying field-overhead damages. This approach supports such fair apportionment.

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Undoubtedly, it is more equitable and reasonable to apportion damages in concurrent delay circumstances. Current practice reveals that courts and boards can adopt the doctrine of comparative negligence for solving concurrent delays. However, the research literature mostly discusses concurrent delays between owners and contractors. It does not get into the level of detail that this paper does. Therefore, the only critique that can be offered is that previous writers have glossed over such important issues. This paper focuses on concurrent delays at the subcontract level.

Case Law Background

One of the greatest areas of conflict between a contractor and subcontractor in a construction project is caused by conflicts related to the timely performance of the work. The effect of construction delays on a project may result not only in claims from the owner against the general contractor, but also between the general contractor and various other contractors affected by the delay. Therefore, the lack of performance by a subcontractor may have an enormous effect on the performance of the project.

Acme Process Equip. Co. v. United States – 1965

When a contractor has attempted to impose liquidated damages under a situation of mutual delay, the courts in the past have generally not attempted to apportion the damages, but have simply held that the provisions of the contract with reference to liquidated damages be annulled. The courts had adopted such a rule to avoid speculation regarding the relative delay caused by the parties. *Acme Process Equip. Co. v. United States* (1965) involved the denial of liquidated

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damages upon a finding of mutual delay. In *Acme* the court stated: "[W]here delays are caused by both parties to the contract the court will not attempt to apportion them, but will simply hold that the provisions of the contract with reference to liquidated damages will be annulled."

Pathman Construction Company v. Hi-Way Elec. Company – 1978

The case *Pathman Construction Company v. Hi-Way Elec. Company* (1978) broke new ground in that the court apportioned delay days between the GC and sub on a pro-rata basis. This case was an action for damages sustained by the plaintiff, Pathman (the GC), allegedly due to the delay of defendant, Hi-way (the electrical subcontractor), in performing its work under a subcontract agreement.

As part of their scope of work Hi-way was required to install header duct, hollow tubing through which electrical conduit is run, upon the cellular decks installed under Pathman's supervision. The first serious problem relating to Hi-way's progress involved its late submission of the shop drawings and material lists required by the subcontract. The second phase of the project for which damages were sought against Hi-way included the installation of ceiling light fixtures. At the conclusion of construction the project owner, the General Services Administration (GSA), withheld $50,000 from its final remittance to Pathman as liquidated damages for the 122 days the entire project had been delayed. Pathman filed an action to recover damages attributable to Hi-way's alleged delay in performing under the subcontract. Hi-way counterclaimed, demanding a setoff in the amount of $56,711.18 for extra work performed and damages allegedly sustained due to Pathman's failure to properly supervise the project.

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The trial court found that Hi-way was responsible for delaying the installation of header duct 49 of the 69 days alleged by Pathman. With regard to the light fixtures, the court found that Hi-way was responsible for 29 days of the 45-day delay claimed by Pathman. However, as a total figure, the court held Hi-way responsible for only 74 days of the entire 122 days the project had been delayed. In calculating damages, the trial court held Hi-way liable to Pathman for $110,000 or 74/122 (approximately 60%) of the $170,312 in total damages claimed by Pathman. The trial court dismissed Hi-way's counterclaim for negligent supervision but awarded Hi-way $17,446.07 on its counterclaim for extra work performed on the project. Accordingly, the trial court entered a judgment in favor of Pathman for the net amount of $92,553.93.

Calumet Constr. Corp. v. The Metropolitan Sanitary District of Greater Chicago – 1988

In the case of *Calumet Construction Corporation v. The Metropolitan Sanitary District (MSD) of Greater Chicago* (1988), Calumet sought damages for certain alleged breaches of the contract by the MSD, as well as the return of liquidated damages which the MSD had withheld from the monies it owed Calumet for delays in Calumet's performance under the contract. Calumet argued that because the MSD contributed to the delays in the work and fault could not be apportioned under the liquidated damages clause of the contract, the entire amount of liquidated damages, $346,000, should be returned to Calumet. The MSD argued that, pursuant to the terms of the contract, it had granted day-for-day extensions to Calumet for the delays it (the MSD) had caused, that there was a question of fact concerning who was responsible for the additional alleged delays, and that, contrary to Calumet's contention, the liquidated damages could be apportioned on the basis of fault under the terms of the contract and was, thus, enforceable.

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The MSD contended that the court should adopt the modern rule of apportionment and enforce the liquidated damages provision accordingly. It argued that the policy behind the rule of apportionment was sound, especially in complex construction contracts such as the one presented here, because in these types of cases there will always be at least some delay, albeit unintentional, attributable to the owner. If the court were to adopt the harsh rule of nonapportionment, it argued, the end result would be that liquidated damages clauses would never be enforceable in the large, complex construction contracts for which they were intended, since there will always be some unintentional delay attributable to the owner. Thus, the MSD concluded that the trial court should have enforced the liquidated damages clause and applied the modern rule of apportionment.

The court found no merit in Calumet's contention that it is too difficult to apportion fault under a liquidated damages clause, and concluded:

> "[A] court would have no more difficulty ascertaining proportional fault under a liquidated damages clause than it would in a case of comparative negligence involving actual damages. Hence, we conclude that the older rule of nonapportionment is too harsh and not in accord with current policy in cases concerning a valid liquidated damages clause. We, therefore, hold that the modern rule of apportionment should be applied here."

The United States of America for the use of Belt Con Construction, Inc. v. Metric Construction Co., Inc.; Safeco Insurance Company of America – 2009

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This case involved a concurrent delay dispute, among other things, between Belt Con (masonry subcontractor) and Metric (general contractor). This dispute arose when Metric withheld final payment from Belt Con due to Belt Con's contribution to inexcusable delays. Belt Con's expert testified in some of the Belt Con-caused delay was non-critical and some was concurrent with delay caused by the concrete subcontractor. The District Court ruled in favor of Belt Con because Metric distributed full delay responsibility to Belt Con regardless of the contributions of other subcontractors (i.e., concrete subcontractor). The U.S. Court of Appeals upheld the District Court citing that "Metric did not allocate concurrent damages in good faith." The District Court reasoned:

> "Metric is correct that the Court can, where appropriate and the evidence so supports, apportion delay… The Court will not hesitate to undertake that task where appropriate. Metric has not, however, with its factual presentation or its legal arguments, convinced the Court that it should do so in this case."

This decision indicates that though apportioning concurrent delays is allowable at the subcontract level, courts will not support this if a general contractor does not appropriately apportion responsibility for delay among its subcontractors. In this particular case, the District Court "did not find [Metric's experts'] methodology, evidence, or testimony reliable."

Assessment of Court Cases

These cases illustrate a progression, over the course of three decades, in the court's view on apportionment. The courts included both the United States Supreme Court and a state appellate court. The cases range from a general contractor versus a local agency (GC/owner), a general

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contractor versus a subcontractor (GC/sub), and the federal government versus a supplier (owner/supplier).

The Pathman case is interesting in that the court ruled that when there is sufficient evidence to make a reasonably certain division of responsibility for delay, the assessment of damages may be allocated among the parties. Although the task before the court in Pathman was particularly difficult, since the performance of the work was sequential and the delay was the result of multiple causes, the court decided that it was not impossible to apportion delays. This was reinforced in Calumet, where the court reaffirmed their right and ability to apportionment. Technological advances and use of computers to devise work schedules and chart progress on a particular project have facilitated the court's ability to allocate damages. Therefore, the court is not reluctant to allocate responsibility for actual damages resulting from mutual delay among the parties if it is supported by sufficient evidence.

As a general rule the plaintiff carries the burden of proving a delay claim, the extent of the delay, and that they were harmed by the delay. According to well-settled law, the party claiming delay damages must demonstrate (1) what delays occurred; (2) whether the delays are compensable; (3) who caused the delays; (4) whether the delay was offset by concurrent delays such as the delays of the opposing party or by compensable delays; and (5) the relationship between the delay and damages claimed (Hart, 2006). In establishing a causal link between delay and the damages claimed, a contractor must demonstrate that the contractee's actions affected activities on the critical path of the contractor's performance of the contract. The party seeking damages for the

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delay bears the burden of establishing with a reasonable degree of certainty that damages were caused and the amount of the damages.

The court ruled in *Premier Electrical Construction Company v. American National Bank of Chicago* (1995) that apportionment of damages in a case of mutual delay is a question of fact, and the burden is on the party claiming such damages to prove that the damages were caused by default of the party charged, separate from any damages that may have resulted from the acts of the claimant. When there is sufficient evidence to allow the court to make a reasonably certain division of responsibility for delay, the assessment of damages may be allocated among multiple parties, even though the performance of work is sequential and the delay is the result of many causes (Carter et al.,1992). However, damages must be proven with reasonable certainty to assure a fair and just result – the claimant can meet this requirement by presenting a before-and-after comparison accompanied by a plausible, though not necessarily conclusive, connection between the baseline and as-built schedules and the associated wrongdoing of the defendant.

The following section shows different ways that this comparison can be expressed as a way to apportion delays. They are alternatives for general contractors and subcontractors when negotiating and apportioning damages of concurrent delays. They can also help legal bodies solve future disputes as to concurrent delays at the subcontract level. A hypothetical case study is also presented to demonstrate the proposed apportionment alternatives.

Proposed Apportionment Methods

As previously discussed the courts have only recently examined apportioning delay damages among a general contractor and subcontractor(s), where concurrent delays occur. If a concurrent delay is caused by the owner and contractor, the contractor is typically granted only a time extension. However, when a concurrent delay is caused by the general contractor and subcontractor(s), it is apparent that this concurrent delay is truly an inexcusable delay. As such the general contractor has to pay the owner actual or liquidated damages. This requires that the general contractor seek an acceptable method for distributing these damages among responsible parties. Unfortunately, such a method is not always available.

For that reason potential practices are presented to apportion damages of concurrent delays in this case study. They are 1) company count-, 2) contract value-, 3) direct cost-, and 4) labor hour-based methods. Requirements and details of data generally differ from this practice to another. Depending on availability and acceptability of data, the last three methods either use original or actual data to evaluate apportioning weights.

Company Count-Based Apportionment

The company count-based method shares delay damages equally to each corporate party who contributed to a certain concurrent delay. The method is very easy to use and generally requires the least amount of project data. However, apportionment is arbitrary and often unreasonable because it does not take into account different levels of effort of parties responsible. The formula for apportioning damages is as follows:

$$\text{Damages Paid by a Party Responsible} = \frac{\text{Actual or Liquidated Damages}}{\text{Number of Parties Responsible}}$$

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Contract Value-Based Apportionment

This method uses contract values to calculate apportioning weights. Contract values are specified in either original or modified contracts. These monetary values are proportional or representative for company involvement in the project. It is moderately easy to use. Contract values are almost always available yet it is sometimes difficult to distribute them to delayed activities and/or delay period under assessment. The general formula is:

Damages Paid by the ith Party Responsible =

$$\frac{\text{Contract Value of Party i}}{\Sigma \text{ Contract Values of Parties Responsible}} \times \text{Actual or Liquidated Damages}$$

Direct Cost-Based Apportionment

This method uses direct costs to calculate apportioning weights. Again, direct costs are either estimated or actual. Advantages and disadvantages are similar to those of the contract value-based apportionment. However, direct costs are typically more difficult to obtain compared to contract values. The general formula is also similar to contract value-based apportionment:

Damages Paid by the ith Party Responsible =

$$\frac{\text{Direct Cost of Party i}}{\Sigma \text{ Direct Costs of Parties Responsible}} \times \text{Actual or Liquidated Damages}$$

Labor Hour-Based Apportionment

This method uses labor hours to calculate apportioning weights. Similar to contract value- and direct cost-based methods, labor hours are either planned or actual. It is somewhat easy to use.

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However, labor hours are not readily accessed for delayed activities and delay periods unless project data are well-maintained and updated. The general formula is also similar to those of the above methods:

Damages Paid by the i^{th} Party Responsible =

$$\frac{\text{Labor Hours of Party i}}{\Sigma \text{ Labor Hours of Parties Responsible}} \text{ x Actual or Liquidated Damages}$$

Hypothetical Case Study

The following case study is used to illustrate different practices for apportioning damages between a general contractor and his subcontractors and suppliers. The rationale for using a hypothetical project is that we can amply demonstrate the variability that results from the different apportionment methods. Hypothetical case studies have been widely used for similar purposes in literature (i.e., Hegazy and Zhang 2005; de la Garza et al. 2007; Sakka and El-Sayegh 2007; Nguyen and Ibbs 2008).

Description

A warehouse construction project has nine major activities that are performed by different parties. Table 1 shows these activities, their durations, predecessors, and responsible parties. Responsible parties include the general contractor and five subcontractors, namely subs A, B, C, D, and E. The original project duration is 70 days (Figure 1). The contract between the owner and general contractor stipulates $30,000 per day as liquidated damages.

<Insert Table 1 and Figure 1 about here>

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During construction, the project was delayed 10 days. Table 2 summarizes delaying events occurring on seven activities. Excavation was delayed one day due to unanticipated inclement weather. The shortage of ready-mixed concrete delayed the installation of footings four days. Offsite steel frame fabrication was extended 10 days because the supplier of sub A failed to deliver cold-formed steel on time. Similarly, subs B, C, D, and E failed to finish their activities as planned. Specifically, roofing, walls and doors, mechanical work, and electrical work were delayed two, five, five, and two delays, respectively. The next two sections present how current practices analyze and apportion delays and their financial impacts.

<Insert Table 2 about here>

Delay Analysis

Delay analysis is needed to identify delay responsibility since many delaying events occurred during the warehouse construction. Figure 2 depicts the as-built schedule, with solid bars presenting actual activities. The baseline or as-planned schedule is also incorporated for comparison. The actual project duration was 80 days. In this case, schedule window analysis is employed for apportioning delay days. It is the best available option for delay analysis (Finke, 1999). Discussion of this method and others are beyond the scope of this paper.

<Insert Figure 2 about here>

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Table 3 summarizes the results of the window analysis. Based on the delaying events, five reasonable windows are dates 1 – 11, 12 – 35, 36 – 37, 48 – 72, and 72 – 80. Accordingly the ten-day project delay includes: one-day excusable and non-compensable; four-day concurrent between general contractor and subcontractor A; two-day concurrent among subcontractors C, D, and E; and three-day inexcusable by subcontractor D. Thus nine of the ten delay days are inexcusable from the viewpoint of the owner. On one hand the general contractor has to pay \$270,000 (9 days x \$30,000) liquidated damages to the owner. On the other hand the general contractor needs to apportion this amount of financial damages to him/herself and his/her subcontractor(s).

<Insert Table 3 about here>

Apportionment of Damages

Table 4 shows cost data for this warehouse construction project; including contract values, direct costs, and labor hours for various work packages. In turn each of them consists of both original (bid) and actual (final) data. Based on the proposed apportionment methods, delay damages can be apportioned and allocated to the general contractor and its subcontractors.

<Insert Table 4 about here>

Taking window number 4 (dates 48 – 72, Table 3) as an example, we can distribute delay damages to responsible parties using the four proposed apportionment methods as follows:

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- Company count-based apportionment: Damages Paid by Sub C (or D, E) = (2 x 30,000)/3= $20,000.
- Contract value-based apportionment with the use of original contract values: Damages Paid by Sub C = [200,000/(200,000 + 150,000 + 100,000)] x 2 x 30,000 = $26,667.
- Direct cost-based apportionment with the use of original direct costs: Damages Paid by Sub C = [180,000/(180,000 + 120,000 + 85,000)] x 2 x 30,000 = $28,052.
- Labor hour-based apportionment with the use of original labor hours: Damages Paid by Sub C = [960/(960 + 2,400 + 1,680)] x 2 x 30,000 = $11,429.

Table 5 summarizes apportionment outcomes with the calculation process similar to the above example. That is, the distributions of damages to the general contractor and subcontractors in windows 2 and 5 are similar to those in window 4. Table 5 does not include windows 1 and 3 because there is either no delay or excusable delay in these windows.

<Insert Table 5 about here>

Discussion

Apportionment analysis is far from consistent. Different practices obviously yield different apportionment results. This reveals that the null hypothesis is not accepted because the case study demonstrates substantial differences in the outcome depending on which apportionment methodology is chosen. For instance, the general contractor has to pay apportioned damages ranging from $18,113 (original direct cost-based) to $60,000 (company count-based). This

explains why apportionment of damages in concurrent delays between a general contractor and subcontractors or among subcontractors is controversial and often causes disputes. In addition, whether contract values, direct costs, and labor hours for the whole (sub)contracts, for only delayed activities, or for only delay periods under assessment are used in the proposed methods to apportion damages is contentious. This is because each contract or subcontract may consist of many activities that are performed in different periods of time yet delaying events only impact some activities in some time periods. As such, within an apportionment method, results can be inconsistent. It should be noted that the apportionment analysis for this case study (Table 5) uses contract values, direct costs, and labor hours of delayed activities.

Subcontracts should specify which apportionment method/practice will be used if concurrent delays occur to deal with result inconsistency between and within methods. This also guides the parties as to which project data must be recorded for apportionment analysis if concurrent delays really occur. For example, in *Virginia Beach Mechanical Services, Inc. v. Samco Construction Company* (1999), the subcontractor (Mechanical Services, Inc.) faced the burden of proving delay damages. The Court ruled that the subcontractor did not provide a reasonable basis for apportioning damages among the general contractor (Samco) and other subcontractors, who were apparently a critical factor in the delay that occurred (Hart, 2006).

The above methods are similarly applied to the case of distributing the general contractor's damages to subcontractors who caused concurrent delays. The case study demonstrates how liquidated damages that the general contractor has to pay to the owner are apportioned between the general contractor and his/her subcontractors. Some subcontracts nevertheless have a

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liquidated damages clause, or the like, that the general contractor can use to recover delay damages. Additionally, liquidated damages that a general contractor accesses from his/her subcontractors may be limited to the amount the general contractor has paid the owner (Kelleher, 2005). For instance, in *Hall Construction Company v. Beynon* (1987), the Florida District Court of Appeals held that the contractor's recovery of delay damages was limited to the amount paid to the owner since a purchase order to a supplier contained a pass-through of the liquidated damages clause. Thus, the subcontracts should also stipulate under what circumstances apportionment analysis will be applied.

Conclusions

Proper apportionment of damages in concurrent delay from a general contractor-subcontractor perspective is both noteworthy and imperative. There is no universally-agreed upon approach for apportioning delay damages when there is a concurrent delay by multiple subcontractors or between the general contractor and other subcontractor(s). This paper has presented different approaches for apportioning damages for concurrent delays caused by the general contractors and his/her subcontractors. They include company count-, contract value-, direct cost-, and labor hour-based apportionment analyses. It shows that results are very inconsistent between and within the apportionment practices. This does not support the null hypothesis that apportionment is not a significant issue. The case study demonstrates substantial differences in the outcome depending on which apportionment approach is used. Subcontracts should specify which apportionment method/practice will be used when concurrent delays occur, in order to deal with the resultant inconsistency between and within methods. They should also stipulate under what

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circumstances apportionment analysis will be applied. Future research is needed to develop a more reliable method for this kind of apportionment.

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Captions for Tables and Figures

Figure 1

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Figure 1. As-planned schedule

ID	Activity Description (Responsible Party)	Duration
1	**Warehouse Project**	**70 days**
2	**Substructures**	**30 days**
3	Excavation (GC)	10 days
4	Footing (GC)	20 days
5	**Superstructures**	**35 days**
6	Offsite fabrication (Sub A)	25 days
7	Steel frame installation (GC)	5 days
8	**Finishes**	**35 days**
9	Roofing (Sub B)	5 days
10	Walls and doors (Sub C)	20 days
11	Mechanical work (Sub D)	30 days
12	Electrical work (Sub E)	30 days
13	Floor and ceiling (GC)	5 days

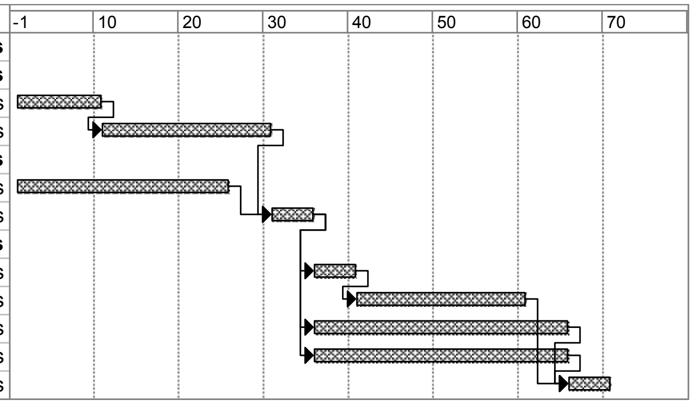

Figure 2

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Figure 2. As-built schedule

ID	Activity Description (Responsible Party)	Baseline Duration	Actual Duration
1	**Warehouse Project**	**70 days**	**80 days**
2	**Substructures**	**30 days**	**35 days**
3	Excavation (GC)	10 days	11 days
4	Footing (GC)	20 days	24 days
5	**Superstructures**	**35 days**	**40 days**
6	Offsite fabrication (Sub A)	25 days	35 days
7	Steel frame installation (GC)	5 days	5 days
8	**Finishes**	**35 days**	**40 days**
9	Roofing (Sub B)	5 days	7 days
10	Walls and doors (Sub C)	20 days	25 days
11	Mechanical work (Sub D)	30 days	35 days
12	Electrical work (Sub E)	30 days	32 days
13	Floor and ceiling (GC)	5 days	5 days

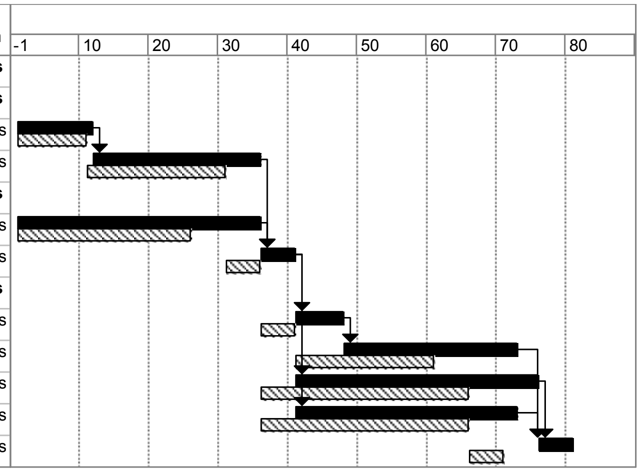

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Table 1. List of activities

Code	Activity	Duration (day)	Predecessors	Responsible Party
1.0	Substructures			GC
1.1	Excavation	10		GC
1.2	Footing	20	1.1	GC
2.0	Superstructures			Varies
2.1	Offsite fabrication	25		Sub A
2.2	Steel frame installation	5	1.2; 2.1	GC
3.0	Finishes			Varies
3.1	Roofing	5	2.2	Sub B
3.2	Walls and doors	20	3.1	Sub C
3.3	Mechanical work	30	2.2	Sub D
3.4	Electrical work	30	2.2	Sub E
3.5	Floor and ceiling	5	3.2; 3.3; 3.4	GC

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Table 2. Actual records of the delayed activities

Activity	Duration	Remark
Excavation	11	1-day inclement weather
Footing	24	Interruption of concrete supply
Offsite fabrication	35	Sub A's supplier delivered cold-formed steel late
Roofing	7	Sub B failed to finish roofing within 5 days
Walls and doors	25	Sub C failed to deliver doors and drywalls on time
Mechanical work	35	Sub D was unable to finish the work in 30 days
Electrical work	32	Sub E delayed this work due to changing the supplier

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Table 3. Delay analysis result

Window No.	Window (Date)	Critical Delay (Day)	Responsibility
1	1 – 11	1	Excusable and noncompensable
2	12 – 35	4	Concurrent: GC and Sub A
3	36 – 47	–	No
4	48 – 72	2	Concurrent: Subs C, D, and E
5	72 – 80	3	Inexcusable: Sub D

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Table 4. Project data

Description	Contract Value ($)		Direct Cost ($)		Labor Hour	
	Original	Actual	Original	Actual	Original	Actual
General Contractor	300,000	330,000	250,500	281,500	1,960	2,168
Excavation	20,000	20,000	14,000	16,000	240	240
Footing	80,000	90,000	64,000	76,500	640	768
Steel frame installation	50,000	40,000	45,000	36,000	400	360
Floor and ceiling	150,000	180,000	127,500	153,000	680	800
Subcontractor A	400,000	450,000	360,000	405,000	2,000	2,800
Subcontractor B	100,000	100,000	85,000	90,000	280	280
Subcontractor C	200,000	200,000	180,000	180,000	960	960
Subcontractor D	150,000	120,000	120,000	102,000	2,400	2,240
Subcontractor E	100,000	150,000	85,000	127,500	1,680	2,048
Total	1,250,000	1,350,000	1,080,500	1,186,000	9,280	10,496

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Table 5. Apportionment results (in dollars)

Window	Party	Company Count	Contract Value-Based		Direct Cost-Based		Labor Hour-Based	
			Original	Actual	Original	Actual	Planned	Actual
2	GC	60,000	20,000	20,000	18,113	19,065	29,091	25,830
	Sub A	60,000	100,000	100,000	101,887	100,935	90,909	94,170
4	Sub C	20,000	26,667	25,532	28,052	26,374	11,429	10,976
	Sub D	20,000	20,000	15,319	18,701	14,945	28,571	25,610
	Sub E	20,000	13,333	19,149	13,247	18,681	20,000	23,415
5	Sub D	90,000	90,000	90,000	90,000	90,000	90,000	90,000
Total	GC	60,000	20,000	20,000	18,113	19,065	29,091	25,830
	Sub A	60,000	100,000	100,000	101,887	100,935	90,909	94,170
	Sub C	20,000	26,667	25,532	28,052	26,374	11,429	10,976
	Sub D	110,000	110,000	105,319	108,701	104,945	118,571	115,610
	Sub E	20,000	13,333	19,149	13,247	18,681	20,000	23,415